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## REVIEWS

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*Climates of Geologic Time.* By CHARLES SCHUCHERT. Carnegie Institution of Washington, Publ. No. 192, pp. 263-98, Figs. 87-90.

There has been a progressive advance, in late years a most rapid one, from the conception of a former hot, dense, vaporous earth atmosphere, the natural corollary of the Laplacian hypothesis. Knowledge of glacial climates, which had its beginning in studies in the Alps early in the eighteenth century, has grown until not only has there been demonstrated a world-wide lowering of temperature with glaciation of much of the Northern Hemisphere in recent geologic time, but there has been proved as well a number of such glacial periods in earlier times. The cold climates which have periodically affected the earth more or less widely since the beginning of geologic history have been of short geologic duration. The data at hand indicate at least four well-marked glaciations: (1) earliest Proterozoic, shown by the widespread "slate conglomerates" at the base of the Lower Huronian in Canada; (2) latest Proterozoic, marked by thick, widespread tillites beneath the Lower Cambrian of Southern Australia, and by the Gaisa formation of Northern Norway, both now thought to be latest Proterozoic instead of Lower Cambrian; (3) Permian, abundantly proven by tillites in many parts of the world, mostly between latitudes 20° N. and 40° S.; and (4) Pleistocene, the deposits of which mantle much of the Northern Hemisphere. Less well-marked cold periods seem to have occurred (5) at another part of the Proterozoic, for the glacial materials of this age in South Africa represent neither the earlier nor the later part of the era; (6) in the Lower Devonian of South Africa, shown by the Table Mountain series, and (7) in the early Eocene, indicated by deposits in the San Juan Mountains of Colorado. The greatest reductions of temperatures, so far as known, varied between the hemispheres.

Guided by the postulate that the living things of sea and land always have been affected by climatic conditions much as now, climate variations are to be observed in the succession of plants and animals recorded as fossils. In addition, the color and general character of the sedimentary deposits afford light on climatic conditions at the time of their

deposition. In spite of widespread glaciation at certain periods, the Proterozoic era had, in the main, a rather warm, equable climate. This is shown by the enormously thick limestone deposits (50,000 feet in Canada), abundance of large Archaeocyathinae, widely distributed graphites, and presence of coal. The Cambrian, with an abundance of shallow-water life, had a uniformly warm temperature which continued into the Ordovician and Silurian. The red shales, gypsum deposits, salt beds, and scant, depauperate fauna of the late Silurian indicate aridity and possible coolness, the latter expressed perhaps by local glaciation (South Africa). The deposits of Northern Europe in the Devonian probably marked a cool, somewhat arid climate, and the great change in the life-forms in the Middle Devonian may be further evidence of the same thing. The climate of the middle and later part of the Devonian was warm; that of the Carboniferous, warm-temperate to subtropic. The great variety of marine life, abundance of reef corals in high latitudes, extensive coal deposits, subtropical flora, and large-sized insects, all suggest this. The adverse climate of the Permian is clearly shown in the glacial tillites, red shales, salt and gypsum deposits (to thickness of 3,300 feet), and depauperate, scanty fauna. The sweeping change in the types of life seen in the Triassic is most convincing proof of climatic severities at this time. Large trees (to 8 feet diameter), and their absence of rings, luxuriant ferns, and thick deposits of limestones in high latitudes, all suggest warmth. The late Triassic-Lias probably saw a reduction of temperature, for of the Triassic ammonites (1,000 species) none passed into the Jurassic, the insects were uniformly dwarfed, and the corals, both numerically and geographically, were very much restricted. The Jurassic was a period of remarkably warm, equable climate. The wide distribution and variety of ammonites (15,000 species), their presence with corals and marine saurians in very high latitudes, and the very cosmopolitan, luxuriant floras are to be noted. The Comanchean-Cretaceous marks the introduction of hardwood forests and may indicate a cooler climate than the Jurassic; but the presence of magnolias in Greenland and Alaska shows at least warm-temperate conditions there. The Cretaceous is distinguished by a remarkable deployment of the immense land reptiles and very thick limestone deposits. Climatic conditions in the Tertiary are not sharply different from those of the Cretaceous. Middle and late Eocene floras show many tropical marks, Oligocene faunas are varied and large sized, especially the foraminifers (nummulites), the Miocene shows a distribution of warm-temperature plants in Spitzbergen and Grinnell Land, but the late Miocene was, at

least in many places, cooler. The Pliocene was rather warm but undoubtedly became colder toward the beginning of the Pleistocene when glacial conditions reached full expression.

The author concludes that the marked climatic variations of the past are primarily due to periodic changes in the topography of the land surface, modified by the variations in the amount of heat stored in the oceans, and the change in the composition of the atmosphere which conditions the storage of solar radiation. Supplementary notes with quotations from original descriptions of pre-Permian tillites and a bibliography of the subject are appended.

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*Oceania.* By P. MARSHALL. Handbuch der regionalen Geologie, 5. Heft, Band VII, Abteilung 2. Heidelberg, 1912. Pp. 36, figs. 10.

Oceania, limited on the west by the Marianne, Pelew, and Caroline islands, on the east by the Sandwich Islands, is a region measuring about 8,400 miles east and west, and 4,200 miles north and south. Most of the islands are small, aggregated in rather well-defined groups or lines, and within the limits of each group the geological and physical structures are somewhat uniform. With the exception of the largest only, the islands are volcanic or composed of coralline limestone, and almost every island is fringed by coral reefs. The basin of the Pacific is of great, and nearly uniform, depth (2,500–3,000 fathoms), but in the west part of Oceania the ocean depths are far less regular. Very deep troughs are found subparallel to some of the island chains and their connecting submarine ridges, and the location of the shallows and basins is suggestive of important structural relations. The island chains seem to define at least four mountain ranges which are seen to converge toward Northern New Zealand, a region therefore of great structural importance. The true border of the Pacific basin segment of the earth's crust is marked by a fairly definite line, indicated by the submarine elevations, areas of raised coral rock, and the distribution of andesitic rocks. This line passes through the Kermadec, Tonga, Fiji, New Hebrides, and Solomon islands, and is noteworthy as the belt of present volcanic activity. Triassic fossils in New Zealand and New Caledonia indicate their coastal connection in the past, and the present faunal and floral distribution is strongly suggestive of the former existence of a continental area limited by the island line mentioned. Coral growths of the Pacific